MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2016/2017

ETM3136 – DIGITAL COMMUNICATIONS

(TE)

30 MAY 2017
09:00 a.m – 11:00 a.m
(2 Hours)

INSTRUCTION TO STUDENTS

1. This question paper consists of 7 pages with **4** Questions only.

2. Attempt **ALL FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

(a)

(i) State the two requirements which must be satisfied for no distortion at the output of a linear time invariant system. [4 marks]

(ii) Determine which of the following signals shown in figure Q1.1 will pass relatively undistorted through the system $h(t)$ specified below. If a signal is distorted, specify the type of distortion. [6 marks]

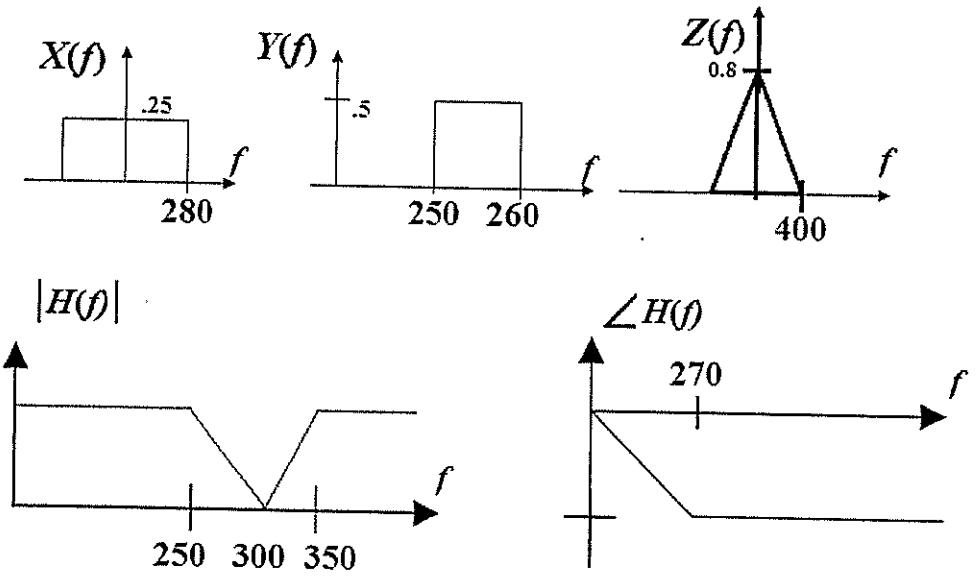


FIGURE Q1.1

(b) A filter shown in Figure Q1.2 has a transfer function $H(f) = \text{rect}(f/2B)$ and input signal with spectrum $X(f) = \text{rect}(f/2W)$.

(i) Sketch $Y(f)$ for $W < B$. [3 marks]

(ii) Sketch $Y(f)$ for $W > B$. [3 marks]

(iii) In which case does the output suffer distortion? [2 marks]

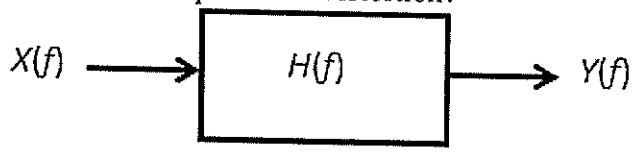


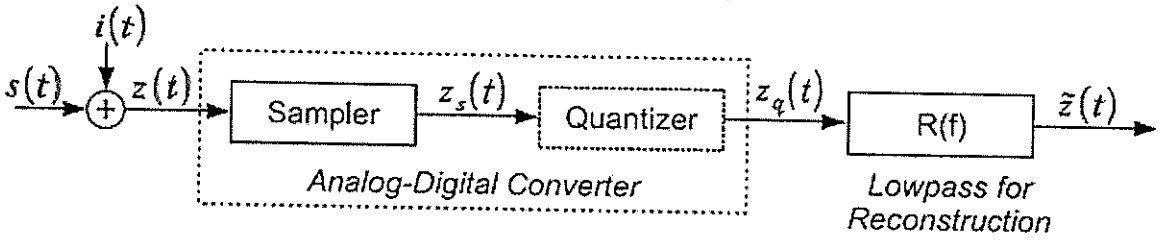
FIGURE Q1.2

(c) Consider a telephone channel with a bandwidth of 45kHz is used to carry 500 kbps of data. The measured signal-to-noise ratio (SNR) is 20dB. Is it possible to obtain error-free transmission? Justify your answer, and in case of no, then propose three system modifications that might be made to have error free transmission. [7 marks]

Continued...

Question 2

(a) Consider $z(t)$ signal as a summation of signal $s(t)$ and noise $i(t)$ as shown in Figure Q2. The $z(t)$ signal digitized by means of an analog-digital converter.



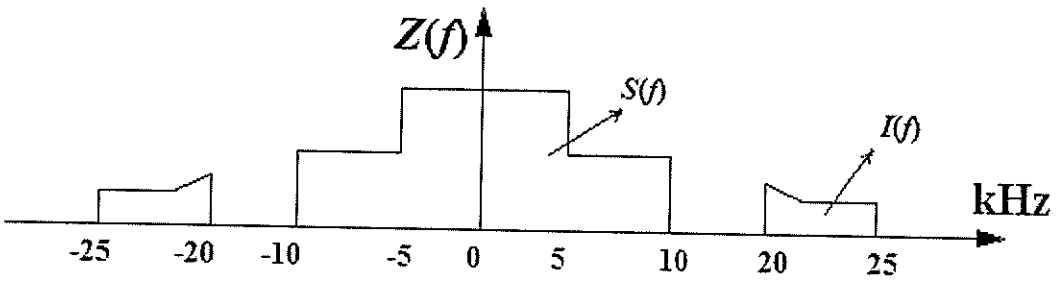


FIGURE Q2

(i) Specify two ways to avoid aliasing errors. [3 marks]
(ii) At what sampling rate, no aliasing occurred [3 marks]
(iii) Draw the magnitude spectrum $|Z_s(f)|$ at the sampler output for the case that f_s = 40kHz. The considered range is $-65\text{kHz} \le f \le 65$ kHz. Label the axis. [4 marks]
(iv) Is it possible to reconstruct the wanted signal $s(t)$ out of $|Z_s(f)|$ without any error using $f_s = 40\text{kHz}$? Justify your answer. [3 marks]

(b) As a telecom engineer you need to design PCM system to modulate an audio signal $m(t)$.

$$m(t) = 3\cos(3000\pi t) + 2.5\cos(5000\pi t)$$

(i) At what sampling rate, no aliasing occurred [3 marks]
(ii) Find the power of the signal [3 marks]
(iii) How many levels and what is the step size should the uniform quantizer has to maintain signal to quantization error ($SQNR$) at 30dB. [3 marks]
(iv) Calculate the digital signal bandwidth if the sampling rate is 60% above the Nyquist rate? [3 marks]

Continued...

Question 3

Let's assume 70km of optical fiber is used to connect central office at Melaka and an optical network unit at Seremban. The optical fiber will carry many user's data. The user's analog signal $m(t)$ is digitized at sampling rate 20000 samples/s. Then encoded by 5-bit encoder. Finally the signal modulated by high modulation technique and occupied a bandwidth 110 KHz in the optical fiber.

(i) As a telecom engineer hired to design this system, what can you do to avoid any intersymbol interference (ISI)? [3 marks]

(ii) What is the appropriate modulation technique will you use for this digital system? Calculate the roll of factor of the Nyquist shape. [7 marks]

(iii) Use pseudo noise (PN) sequence to spread the generated digital date for the proposed system, which is can be generated by linear feedback-shift register of length $m = 7$. A white Gaussian noise (AWGN) with a power spectral density $N_0 = 1\times 10^{-16}$ W/Hz interfered the signal. Then the secured data modulated by the same technique you chose in section (ii).

1. Name two techniques that can be used to spread the digital data. [4 marks]
2. Find the chip rate R_c [3 marks]
3. What is the jamming margin against a continuous tone jammer if the desired error probability is 10^{-9}? [8 marks]

Continued...

Question 4

(a) Consider three-stage switching structure that accommodates $N = 128$ input and 128 output terminals. Compare the number of cross-points required by a non-blocking switch with $n = 32$, $n = 16$, $n = 8$, $n = 4$, and $n = 2$. [7 marks]

(b) Sketch the non-blocking three-stage switching when $N = 128$, and $n = 2$, label all the switches. [3 marks]

(c) What is the maximum number of connections that can be supported at any given time when $N = 128$, and $n = 16$ and 4 intermediate switches? Repeat for 8, 16 and 20 intermediate switches. [8 marks]

(d) If a two-stage switch is used instead of the three-stage switch in (a), calculate the total number of cross-points required by a non-blocking switch when $n = 32$, $n = 16$, $n = 8$, $n = 4$, and $n = 2$. [7 marks]

End of Page

Appendix I

Tabulated values of Q-function

The Q Function (Gaussian Distribution with $\mu = 0$ and $\sigma = 1$)

$$Q(a) = \int_a^\infty \frac{1}{\sqrt{2\pi}} e^{\frac{-x^2}{2}} dx \qquad Q(a) \cong \frac{1}{a\sqrt{2\pi}} e^{\frac{-a^2}{2}} \text{ for } a \geq 3$$

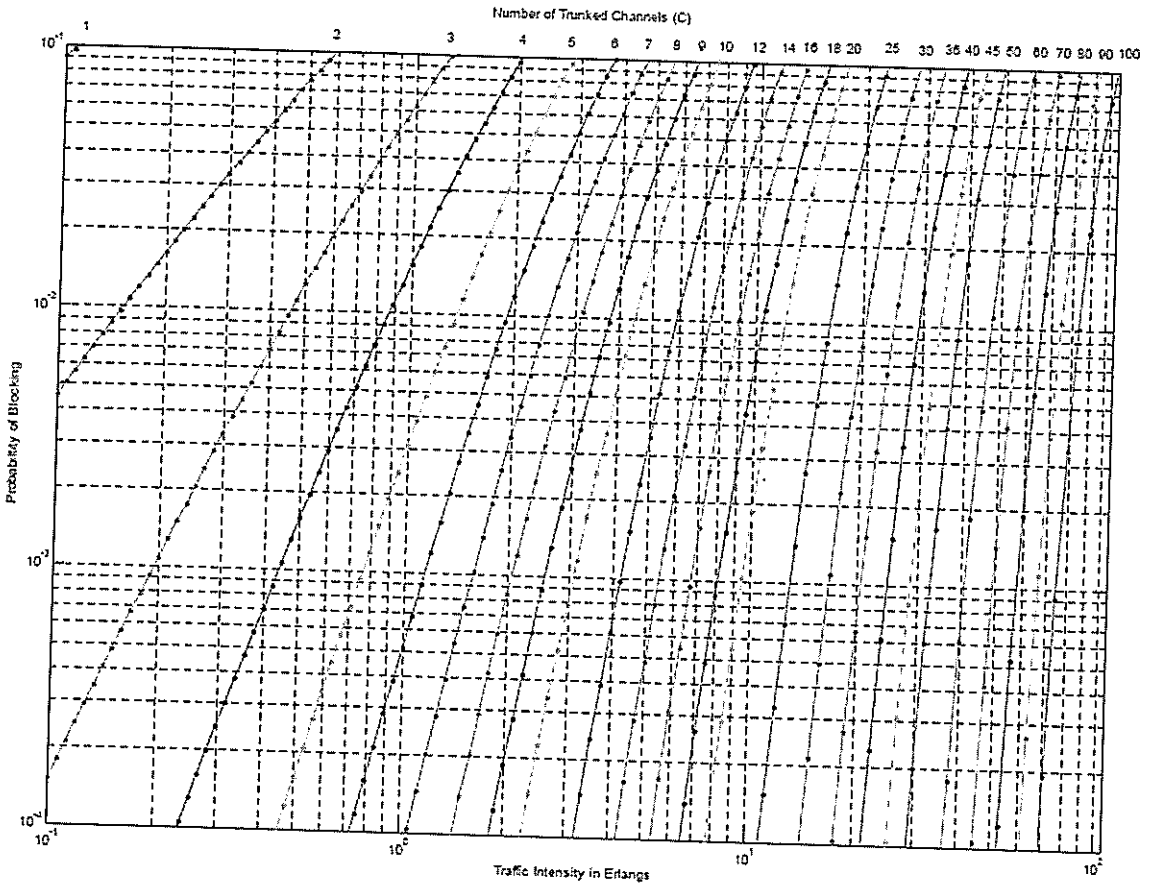
	3rd Significant Digit									
a	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641
0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
0.7	0.2420	0.2389	0.2358	0.2327	0.2297	0.2266	0.2236	0.2207	0.2177	0.2148
0.8	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
1.2	0.1151	0.1131	0.1112	0.1094	0.1075	0.1057	0.1038	0.1020	0.1003	0.0985
1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
1.8	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
2.4	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
2.6	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
2.8	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
2.9	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
3.0	0.0014	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002

$Q(a)$	a
10^{-4}	3.73
5×10^{-5}	3.90
10^{-5}	4.27
5×10^{-6}	4.43

$Q(a)$	a
10^{-6}	4.76
10^{-7}	5.20
10^{-8}	5.61
10^{-9}	6.00

Appendix II

Probability of Call Blocking in an Erlang B System


Number of Trunked Channels (C)
1 2 3 4 5 6 7 8 9 10 12 14 16 18 20 25 30 35 40 45 50 60 70 80 90 100
Probability of Blocking
Traffic Intensity in Erlangs

Hexagonal Cell Area = $2.598\ R^2$

Where R is the radius of the cell